DM Supplement
Stopping Sight Distance

650 Sight Distance

650.01 General

It is essential that the driver of a vehicle be able to see far enough ahead to assess developing situations and take appropriate action. For purposes of design, sight distance is considered in terms of passing sight distance, stopping sight distance, and decision sight distance.

See the following chapters for additional information:

Chapter	Subject
910	Sight distance at intersections at grade
920	Sight distance at road approaches
930	Sight distance at railroad crossings
1020	Sight distance for paths and trails

650.02 References

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT

A Policy on Geometric Design of Highways and Streets, 1994, AASHTO

650.03 Definitions

decision sight distance The sight distance required for a driver to detect an unexpected or difficult-to-perceive information source or hazard, interpret the information, recognize the hazard, select an appropriate maneuver, and complete it safely and efficiently

passing sight distance The sight distance (on a two-lane highway) required for a vehicle to execute a normal passing maneuver as related to design conditions and design speed

sight distance The length of highway visible to the driver

stopping sight distance The sight distance required to safely stop a vehicle traveling at design speed

650.04 Passing Sight Distance

(1) Design Criteria

Passing sight distance is the sum of four distances:

- The distance traveled by the passing vehicle during perception and reaction time and initial acceleration to the point of encroachment on the opposing lane.
- The distance the passing vehicle is in the opposing lane.
- The distance that an opposing vehicle travels during two-thirds of the time the passing vehicle is in the opposing lane.
- A clearance distance between the passing vehicle and the opposing vehicle at the end of the passing maneuver.

Passing sight distance is calculated for a passenger car using an eye height of 3.50 ft and an object height of 4.25 ft. Figure 650-1 gives the passing sight distances for various design speeds.

Design Speed (mph)	Passing Sight Distance (ft)
25	935
30	1,085
35	1,280
40	1,475
50	1,770
60	2,065
70	2,460

Passing Sight Distance
Figure 650-1

On two-lane, two-way highways, provide passing opportunities to meet traffic volume demands. This can be accomplished by using numerous sections with safe passing sight distance or by adding passing lanes at critical locations (Chapter 1010).

In the design stage, passing sight distance can be provided by adjusting the alignment either vertically or horizontally to increase passing opportunities.

These considerations also apply to multilane highways where staged construction includes a two-lane, two-way operation as an initial stage. Whether auxiliary lanes are provided, however, depends on the time lag proposed between the initial stage and the final stage of construction.

(2) Vertical Curves

Figure 650-6 gives the length of crest vertical curve needed to provide passing sight distance for two-lane highways.

Sag vertical curves are not a restriction to passing sight distance.

(3) Horizontal Curves

Passing sight distance can be restricted on the inside of a horizontal curve by roadside objects that are 3.60 ft or more above the roadway surface. When the length of curve is greater than the passing sight distance and the sight restriction is more than half the passing sight distance into the curve, use the following formula to determine if the object is close enough to the roadway to be a restriction to passing sight distance:

$$M = R\left[1 - \cos\left(\frac{28.65\ S}{R}\right)\right]$$

Where:

M = The distance from the center line of the roadway to the obstruction

R = Radius of the curve

S = The passing sight distance from Figure 650-1

When the length of curve is less than the passing sight distance or the sight restriction is less than half the passing sight distance into the curve, the desired sight distance may be available with a lesser M distance. When this occurs, the sight distance can be checked graphically.

(4) No-Passing Zone Markings

A knowledge of practices for marking no-passing zones on two-lane roads is helpful in designing a safe highway. The values in Figure 650-1 are the passing sight distances starting at the point the pass begins. The values in the MUTCD are lower than the Figure 650-1 values. They are for no-passing zone marking limits and start at the point the safe pass must be completed.

The MUTCD values are not to be used directly in design but are discussed for the designer's recognition of locations requiring no-passing pavement markings. Sections of highway providing passing sight distance in the range of values between the distances in Figure 650-1 and MUTCD values require careful review by the designer.

650.05 Stopping Sight Distance

(1) Design Criteria

Stopping sight distance is the sum of two distances; the distance traveled during perception and reaction time and the distance required to stop the vehicle.

Stopping sight distance is calculated for a passenger car using an eye height of 3.50 ft and an object height of 0.50 ft. For various design speeds, Figure 650-2 gives the design stopping sight distances, the minimum curve length for a one percent grade change to provide the sight distance for a crest (K_C) and sag (K_S) vertical curve, and the minimum length of vertical curve for the design speed (VCL_m). Figure 650-3 gives the values for existing stopping sight distance and the associated K_C and K_S.

Provide for design stopping sight distance (Figure 650-2) at all points on all highways and on all intersecting roadways.

Design Speed (mph)	Design Stopping Sight Distance (ft)	K_C	K_S	VCL_m (ft)
25	165	20	28	75
30	200	30	36	90
35	260	51	52	105
40	330	82	70	120
50	460	159	105	150
60	655	323	159	180
70	855	550	215	210
80	1,050	830	271	240

Design Stopping Sight Distance
Figure 650-2

Existing stopping sight distance (Figure 650-3) is used when the vertical and horizontal alignments are unchanged and the sight obstruction is existing.

Design Speed (mph)	Existing Stopping Sight Distance (ft)	K_C	K_S
25	165	20	28
30	200	30	36
35	230	40	44
40	295	65	61
50	395	117	88
60	525	207	123
70	625	294	151
80	755	429	187

Existing Stopping Sight Distance
Figure 650-3

(2) Effects of Grade

The grade of the highway has an effect on the stopping sight distance. The vehicle stopping distance is increased on downgrades and decreased on upgrades. Figure 650-4 gives the stopping sight distances for grades steeper than three percent. When evaluating sight distance with a changing grade, use the grade for which the longest sight distance is needed.

Design Speed (mph)	Stopping Sight Distance (ft)					
	Down Grades			Up Grades		
	3-5%	6-8%	≥9%	3-5%	6-8%	≥9%
25	165	165	165	150	150	150
30	195	215	230	180	180	165
35	260	280	295	215	215	215
40	330	360	375	260	260	245
50	490	540	590	360	345	330
60	690	740	785	460	445	425
70	920	1,000	—	575	540	—
80	1,130	—	—	690	—	—

Design Stopping Sight Distance on Grades
Figure 650-4

(3) Crest Vertical Curves

Use Figure 650-7 to find the minimum crest vertical curve length to provide stopping sight distance when given the algebraic difference in grades. The length can also be determined by multiplying the algebraic difference in grades by the K_C value from Figure 650-2 for design or 650-3 for existing ($L=K_C*A$). Both the figure and the equation give approximately the same length of curve. Neither the figure nor the equation uses the sight distance greater than the length of curve equation. When the sight distance is greater than the length of curve and the length of curve is critical, the S>L equation given on Figure 650-7 may be used to find the minimum curve length.

When a new crest vertical curve is built or an existing one is rebuilt, provide Design Stopping Sight Distance from Figure 650-2. An existing crest vertical curve with Existing Stopping Sight Distance from Figure 650-3 may remain in place.

(4) Sag Vertical Curves

Use Figure 650-8 to find the minimum length for a sag vertical curve when given the stopping sight distance and the algebraic difference in grades. The minimum length for a sag vertical curve can also be determined by multiplying the algebraic difference in grades by the K_S value from Figure 650-2 for design or 650-3 for existing ($L=K_S*A$). Both the figure and the equation give approximately the same length of curve. Neither the figure nor the equation uses the sight distance greater than the length of curve equation. When the sight distance is greater than the length of curve and the length of curve is critical, the S>L equation given on Figure 650-8 may be used to find the minimum length of curve.

When a new sag vertical curve is built or an existing one is rebuilt, provide Design Stopping Sight Distance from Figure 650-2. An existing sag vertical curve with Existing Stopping Sight Distance from Figure 650-3 may remain in place.

(5) Horizontal Curves

Use Figure 650-9 to check for adequate stopping sight distance where sight obstructions are on the inside of a curve. A stopping sight distance obstruction is any object 2 ft or greater above the roadway surface (such as median barrier, guardrail, bridges, walls, cut slopes, wooded areas, and buildings). Figure 650-9 (both the equation and the graph) are for use when the length of curve is greater than the sight distance and the sight restriction is more than half the sight distance from the end of the curve. When the length of curve is less than the stopping sight distance or the sight restriction is less than half the stopping sight distance into the curve, the desired sight distance may be available with a lesser M distance. When this occurs, the sight distance can be checked graphically.

Provide Design Stopping Sight Distance from Figure 650-2 for horizontal curves as follows:

- For all new roadways
- When the roadway is widened
- When there is an alignment shift
- For new features (such as median barrier, bridges, walls, or guardrail)
- When additional right of way is required for roadside improvements

When design stopping sight distance is not required, existing features that have Existing Stopping Sight Distance from Figure 650-3, may remain in place.

650.06 Decision Sight Distance

Decision sight distance values are greater than stopping sight distance values because they give the driver an additional margin for error and afford sufficient length to maneuver at the same or reduced speed rather than to just stop.

Provide decision sight distance where highway features create a likelihood for error in information reception, decision making, or control actions. Example highway features include interchanges and intersections; changes in cross section at toll plazas, drop lanes, etc.; and areas of concentrated demand where sources of information compete, as those from roadway elements, traffic, traffic control devices, and advertising signs. If possible, locate these highway features where decision sight distance can be provided. If this is not possible, use suitable traffic control devices and positive guidance to give advanced warning of the conditions.

Use the decision sight distances in Figure 650-5 where highway features require complex driving decisions.

Design speed (mph)	Decision Sight Distance for Maneuvers (ft)				
	A	B	C	D	E
30	230	510	460	510	625
40	345	725	605	725	825
50	510	985	755	900	1,030
60	690	1,310	1,000	1,150	1,280
70	900	1,525	1,100	1,310	1,460
80	1,100	1,790	1,360	1,425	1,640

Decision Sight Distance
Figure 650-5

The maneuvers in Figure 650-5 are as follows:

A. Rural stop

B. Urban stop

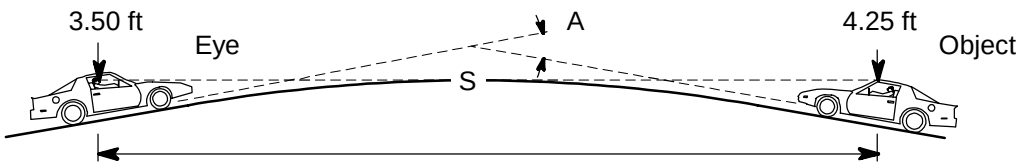
C. Rural speed/path/direction change

D. Suburban speed/path/direction change

E. Urban speed/path/direction change

Decision sight distance is calculated using the same criteria as stopping sight distance; 3.50 ft eye height and 0.50 ft object height. Use the equations on Figures 650-7, 8, and 9 to determine the decision sight distance at vertical and horizontal curves.

P65:DP/DME



Formulas:

When S is less than L

$L = AS^2/3093$

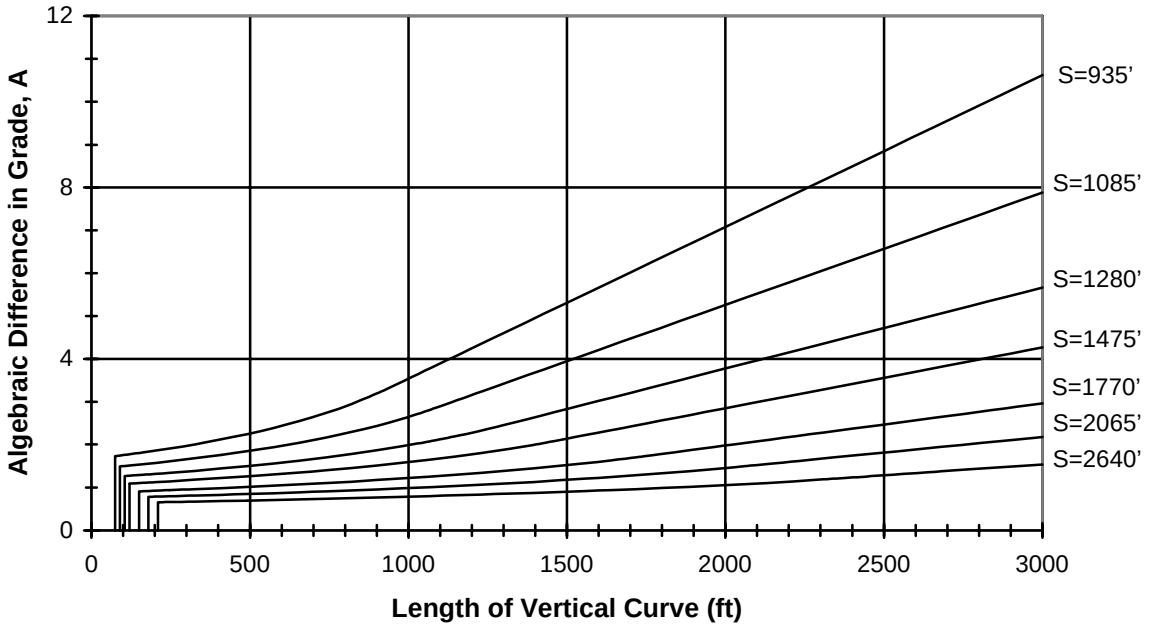
When S is greater than L

$L = 2S - 3093/A$

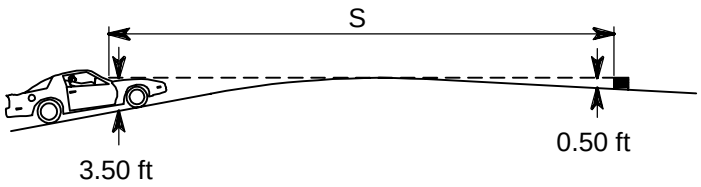
S = Sight distance in feet

L = Length of vertical curve in feet

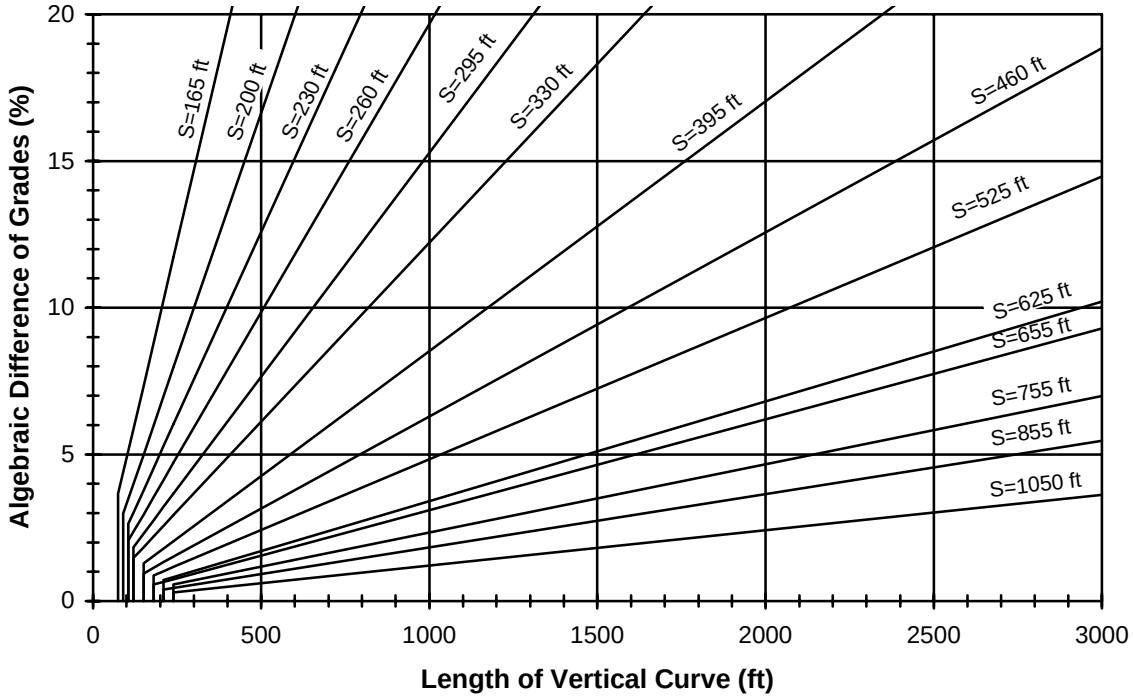
A = Algebraic difference of grades in percent



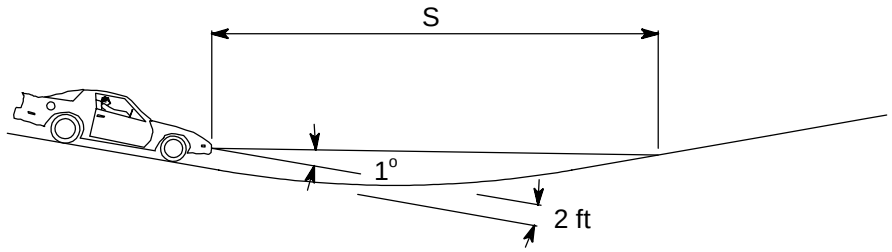
Passing Sight Distance for Crest Vertical Curves
Figure 650-6



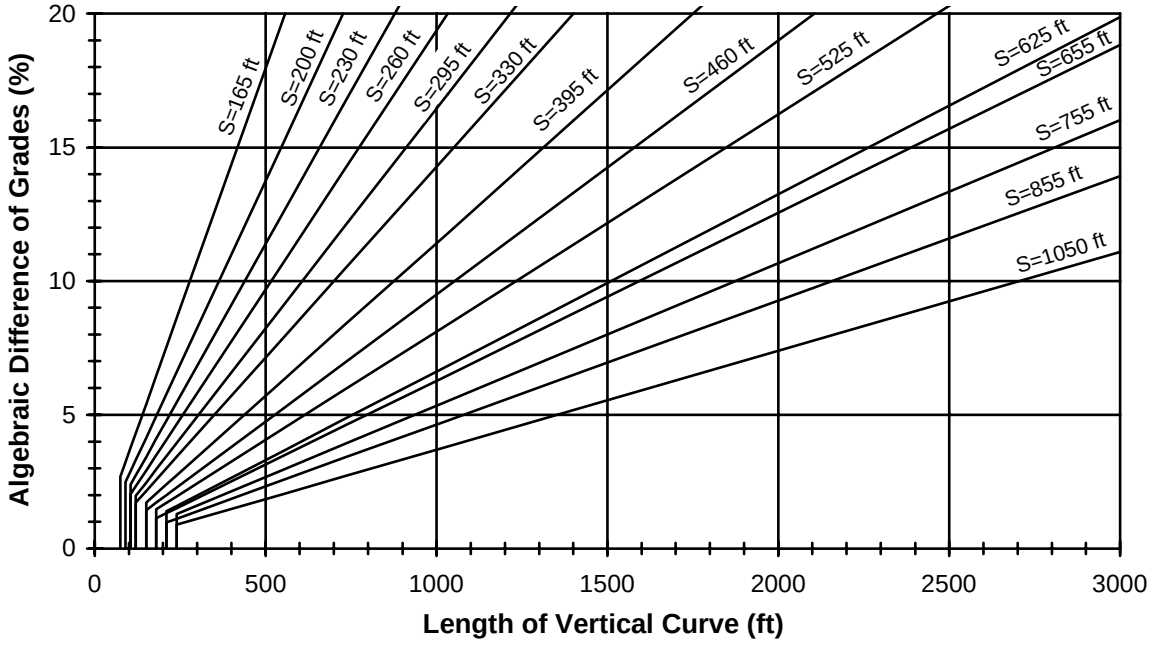
When S > L	When S < L
L = 2S - 1329/A (not used in figure)	L = AS^2/1329
L = Curve length (ft) A = Algebraic grade difference (percent) S = Sight distance (ft)	



Stopping Sight Distance for Crest Vertical Curves
Figure 650-7

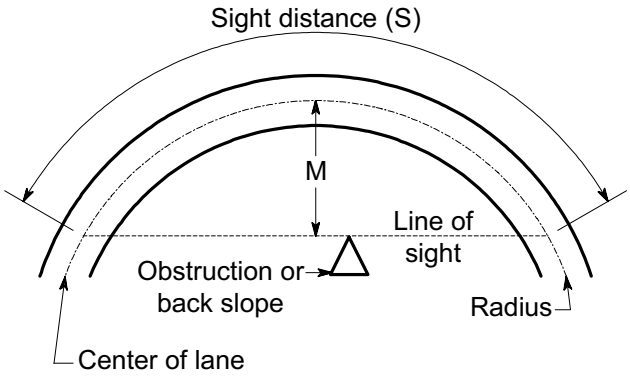


When S > L	When S < L
$L = 2S - \frac{400 + 3.5S}{A}$ (not used in figure)	$L = \frac{AS^2}{400 + 3.5S}$
L = Curve length (feet) A = Algebraic grade difference (percent) S = Sight distance (feet)	



Stopping Sight Distance for Sag Vertical Curves
Figure 650-8

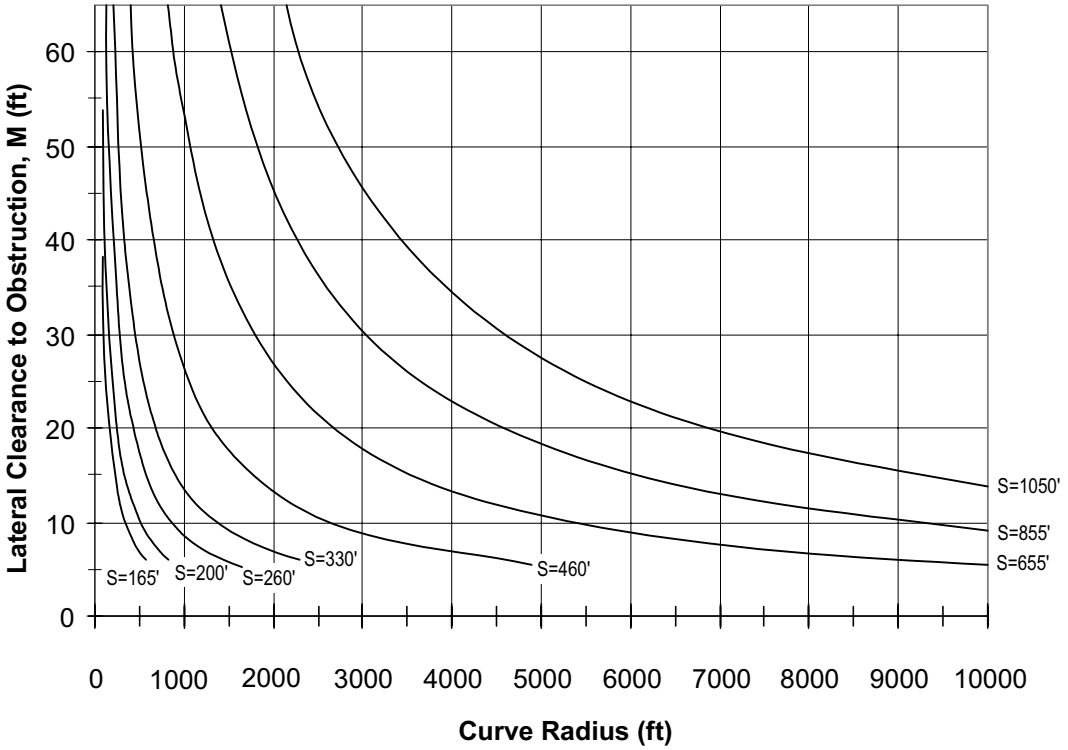
Height of eye: 3.50 ft
Height of object: 0.50 ft
Line of sight is normally 2.00 ft above center line of inside lane at point of obstruction provided no vertical curve is present in horizontal curve.



$$M = R\left(1 - \cos\frac{28.65\ S}{R}\right)$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-M}{R}\right)\right]$$

S ≤ Length of curve
Angle is expressed in degrees



Horizontal Stopping Sight Distance
Figure 650-9